WE CLAIM:

1. An apparatus for depositing a thin film on a substrate, comprising:

a reaction chamber having a reaction space;

a substrate holder for holding the substrate within the reaction space;

a gas outlet in fluid communication with the reaction space;

a gas exchange plate having a first side and a second side, positioned within the reaction chamber, the plate comprising:

a plurality of first passages machined therein being in fluid communication with a first reactant gas source and a purge gas source, the first passages communicating with a plurality of first apertures spaced along the first passages, the first apertures opening to the reaction space;

a plurality of second passages machined therein being in fluid communication with a second reactant gas source and a purge gas source, the second passages communicating with a plurality of second apertures spaced along the second passages, the second apertures opening to the reaction space; and

a plurality of third apertures extending from the first side to the second side of the gas exchange plate, allowing gas to pass therethrough.

2. The apparatus of Claim 1, wherein:

the first passages include a first main passage connected to a plurality of first distributor passages; and

the second passages include a second main passage connected to a plurality of second distributor passages.

3. The apparatus of Claim 2, wherein the first main passage is formed along a first side of the gas exchange plate and the second main passage extends parallel to the first main passage along an opposite side of the gas exchange plate.

4. The apparatus of Claim 3, wherein the first distributor passages extend parallel to the second distributor passages and extend perpendicularly from the first and second main passages, respectively.

5. The apparatus of Claim 4, wherein the first distributor passages alternate with the second distributor passages along an axis parallel to the first and second main passages.

6. The apparatus of Claim 1, further comprising an exhaust plate having a first side and a second side flush with the first side of the gas exchange plate.

7. The apparatus of Claim 6, wherein the gas exhaust plate includes a plurality of exhaust apertures aligned with the third plurality of apertures of the gas exchange plate.

8. The apparatus of Claim 7, wherein the first and second passages comprise grooves on the first side of the gas exchange plate, the exhaust plate overlying and sealing the grooves to enclose the first and second passages.

9. The apparatus of Claim 7, wherein the exhaust plate includes a recess defined in the first side of the exhaust plate and an exhaust conduit communicating from the recess to an edge of the exhaust plate.

10. The apparatus of Claim 10, further comprising a top plate having a first side and a second side, the second side of the top plate fitting with and sealing against the first side of the exhaust plate, thereby sealing and defining an exhaust space within the recess of the exhaust plate.

11. The apparatus of Claim 1, wherein the first, second and third apertures are interspersed with one another and substantially uniformly distributed across the gas exchange plate to provide gas flow substantially uniformly across the substrate holder.

12. The apparatus of Claim 1, wherein the first plurality of apertures are distributed along a plurality of parallel lines and the second plurality of apertures are distributed across a plurality of parallel lines alternated with the parallel lines of the first plurality of apertures.

13. The apparatus of Claim 1, wherein the substrate holder is an end effector of a wafer handler.

14. The apparatus of Claim 1, wherein the substrate holder is a platform comprising a heated susceptor plate.

15. The apparatus of Claim 1, wherein the substrate holder holds the substrate in place by operation of the Bernoulli principle.

16. The apparatus of Claim 1, wherein the plate is positioned below the substrate holder.

17. The apparatus of Claim 16, wherein the substrate holder is a vacuum chuck.

18. The apparatus in Claim 1, wherein the gas outlet is fluidly connected to a vacuum.

19. The apparatus in Claim 1, wherein the gas outlet communicates with a venturi.

20. The apparatus of Claim 1, further comprising controls for alternately providing first reactant to the first plurality of passages while stopping second reactant flow to the second plurality of passages and providing second reactant to the second plurality of passages while stopping first reactant flow to the first plurality of passages.

21. The apparatus of Claim 1, wherein the first and second plurality of passages comprise open grooves on the first side of the gas exchange plate.

22. The apparatus of Claim 21, wherein the grooves comprise rounded bottoms.

23. The apparatus of Claim 21, further comprising first and second holes through an edge of the gas exchange plate, the first and second holes communicating with the grooves of the first and second passages, respectively.

24. The apparatus of Claim 1, wherein the first and second apertures further comprise countersinks widening the first and second apertures at the second side of the gas exchange plate.

25. The apparatus of Claim 24, further comprising countersinks widening the third apertures at the second side of the gas exchange plate.

26. An apparatus for depositing a thin film on a substrate, comprising:

a reaction chamber having a reaction space;

a substrate support, disposed within the reaction space;

a first plate positioned above the substrate support, the first plate having:

a first gas inlet fluidly connected to a first plurality of apertures via a first gas pathway;

a second gas inlet fluidly connected to a second plurality of apertures via a second gas pathway, wherein the first and second pathways are machined into the first plate;

a third plurality of apertures allowing gas to pass through the first plate; and

a second plate fixed to a gas outlet, positioned above the first plate, having a plurality of apertures allowing gas existing between the first plate and the second plate to flow to the gas outlet.

27. A showerhead assembly for a vapor deposition chamber, comprising:

a gas exchange plate having a thickness between a first side and a second side, the gas exchange plate defining a first network of passages in fluid communication with a first gas inlet and a second network of passages in fluid communication with a second gas inlet, the first and second network of passages including a plurality of first and second apertures opening from the first and second network of passages, respectively, to the second side of the gas exchange plate, the first and second apertures being interspersed and spaced across the second side of the gas exchange plate, the gas exchange plate further including a plurality of third apertures extending from the first side to the second side through the thickness of the gas exchange plate and being isolated from the first and second network of passages; and

an exhaust plate having a plurality of exhaust apertures therein, the exhaust plate configured to mate with the gas exchange plate and align the exhaust apertures with the third apertures of the exhaust plate.

28. The showerhead assembly of Claim 27, wherein the first and second networks of passages comprise grooves formed in the first side of the gas exchange plate.

29. The showerhead assembly of Claim 28, wherein the first and second gas inlets comprise holes machined into an edge of the gas exchange plate and in fluid communication with the first and second network of passages, respectively.

30. The showerhead assembly of Claim 28, wherein the exhaust plate has a first side and a second side, the second side of the exhaust plate configured to seal the surface grooves of the first and second network of passages of the gas exchange plate when the second side of the exhaust plate is mated with the first side of the gas exchange plate.

31. The showerhead assembly of Claim 30, wherein the exhaust plate further comprises a recess formed in the first side of the exhaust plate, the recess being in communication with each of the exhaust apertures at a bottom of the recess.

32. The showerhead assembly of Claim 31, wherein the exhaust plate further comprises outlet conduits extending in fluid communication between the recess and an edge of the exhaust plate.

33. The showerhead assembly of Claim 32, further comprising a top plate having a thickness between a first side and a second side, the second side of the top plate configured to mate with and seal against the first side of the exhaust plate, thereby forming an exhaust space within the recess of the exhaust plate.

34. A showerhead plate having a first side and a second side, comprising:

a first flow path through the showerhead plate, the first flow path including a plurality of first apertures opening to the second side of the showerhead plate;

a second flow path through the showerhead plate, the second flow path isolated from the first flow path within the plate, the second flow path including a plurality of second apertures opening to the second side of the showerhead plate; and

a plurality of third apertures extending through the showerhead plate, the third apertures isolated from the first and second flow paths within the showerhead plate.

35. The showerhead plate of Claim 34, wherein the first and second apertures are interspersed and distributed across the second side of the showerhead plate.

36. The showerhead plate of Claim 35, wherein the first and second flow paths each include a main passage and a plurality of distributor passages branching from the main passage.

37. The showerhead plate of Claim 35, wherein the first and second flow paths each include a plurality of connected surface grooves.

38. The showerhead plate of Claim 37, wherein each of the surface grooves includes a rounded groove bottom.

39. The showerhead plate of Claim 37, wherein the first flow path includes a first main passage and a plurality of branching first distributor passages and the second flow path includes a second main passage and a plurality of branching second distributor passages.

40. The showerhead plate of Claim 39, further comprising a first bore extending from an edge of the plate into fluid communication with the first main passage and a second bore extending from an edge of the plate into fluid communication with the second main passage.

41. The showerhead plate of Claim 39, wherein the first and second main passages extend parallel to one another proximate opposite ends of the plate.

42. The showerhead plate of Claim 41, wherein the first and second distributor passages extend parallel to one another and perpendicular to the first and second main passages, the first and second distributor passages alternating with one another along an axis of the main passages.

43. The showerhead plate of Claim 34, wherein each of the apertures includes a countersink.

44. A method of vapor deposition on a substrate housed in a chamber, comprising:

injecting vapor phase reactants through a showerhead plate having a plurality of reactant apertures; and

exhausting exhaust gases through the showerhead plate.

45. The method of Claim 44, wherein exhausting comprises drawing exhaust gases through exhaust apertures in the showerhead plate, the exhaust apertures isolated from the reactant apertures.

46. The method of Claim 44, wherein injecting vapor phase reactants comprises:

injecting a first reactant into the chamber through the showerhead plate in a first pulse; and

injecting a second reactant into the chamber through the showerhead plate in a second pulse separated from the first pulse.

47. The method of Claim 46, further comprising purging the chamber with inert gas supplied through the reactant apertures between adjacent first and second pulses in a plurality of atomic layer deposition cycles.

48. The method of Claim 46, further comprising supplying the first reactant and the second reactant in separated flow paths through the showerhead plate until entering the chamber.

49. The method of Claim 48, wherein the reactant apertures comprise a plurality of first apertures communicating with a first passage in the showerhead plate and a plurality of second apertures communicating with a second passage in the showerhead plate, the first passage being isolated from the second passage.

50. The method of Claim 49, wherein exhausting comprises drawing exhaust gases through exhaust apertures in the showerhead plate, the exhaust apertures are isolated from the first and second apertures and the first and second passages.

51. The method of Claim 50, wherein exhausting further comprises drawing exhaust gases through an exhaust plate overlying the showerhead plate, the exhaust plate having apertures aligned with the exhaust apertures of the showerhead plate.

52. A method of atomic layer deposition, comprising:

providing a gas injection system having injection apertures adjacent a substrate support structure in a reaction space;

supplying separate reactant pulses of a plurality of reactants sequentially through the gas injection system; and

exhausting gases from the reaction space through exhaust paths between the injection apertures of the gas injection system.

53. The method of Claim 52, wherein supplying separate pulses comprises providing temporally separated pulses through physically separated reactant flow paths for each of the reactants.

54. The method of Claim 53, wherein the separated reactant flow paths are physically isolated from the exhaust flow paths.

55. The method of Claim 54, wherein

the gas injection system comprises a showerhead assembly;

the separated flow paths comprise machined passages in a showerhead plate and the injection apertures; and

the exhaust flow paths comprise exhaust apertures extending through the showerhead plate but isolated from the machined passages and the injection apertures.

56. The method of Claim 53, further comprising providing purge gas through all of the reactant flow paths between temporally adjacent reactant pulses.

57. The method of Claim 56, further comprising providing purge gas through a first reactant flow path while supplying a second reactant through a second reactant flow path, and providing purge gas through the second reactant flow path while supplying first reactant through the first reactant flow path.

58. The method of Claim 57, wherein purge gas in one of the reactant flow paths while reactant flows in another of the reactant flow path has a flow rate between about 5% and 20% of a purge gas flow rate between temporally adjacent reactant pulses.

59. The method of Claim 52, wherein supplying pulses comprises at least one cycle including the following steps in sequence:

a first reactant step including injecting a first vapor phase reactant into the reaction space through first apertures of the injection apertures while injecting purge gas through second apertures of the injection apertures;

a first purge step including stopping the first reactant injection and injecting purge gas through the first and second apertures into the reaction space;

a second reactant step including injecting a second vapor phase reactant into the reaction space through the second apertures while injecting purge gas through the first apertures; and

a second purge step including stopping the second reactant injection and injecting purge gas through the first and second apertures into the reaction space.

60. The method of Claim 59, wherein the purge gas flow in the second and first injectors during the first and second reactant steps, respectively, is between about 5% and 20% of the purge gas flow in each injector during the first and second purge steps.

61. The method of Claim 59, further comprising removing gases from the reaction space between the first and second apertures.

62. The method of Claim 59, wherein the first purge step comprises multiple pulses of purge gas flow, each pulse lasting approximately 0.04 – 0.50 seconds.

63. The method of Claim 62, wherein the first purge step comprises between about 2 and 6 pulses of purge gas flow.

64. The method of Claim 62, wherein the second purge step comprises multiple pulses of purge gas, each pulse lasting approximately 0.04 – 0.50 seconds.

65. The method of Claim 59, wherein each of the first and second reactant steps comprise multiple reactant pulses, each pulse lasting approximately 0.04 – 0.50 seconds.

66. The method of Claim 59, wherein gases communicate with the first apertures via a first injector, further comprising flowing purge gas through the first injector via a first

purge channel while flowing the first reactant through the first injector via a first reactant channel during the first reactant step.

67. The method of Claim 66, wherein the first purge step comprises

a booster pulse wherein purge gas is fed to the first injector through each of the first purge channel and the first reactant channel; and

a further purge pulse wherein purge gas is fed through the first injector only through the first purge channel.

68. The method of Claim 67, wherein

gases communicate with the second apertures via a second injector;

the booster pulse further comprises feeding purge gas to the second apertures through each of a second purge channel and a second reactant channel; and

the further purge pulse further comprises feeding purge gas to the second injector only through the second purge channel.

69. The method of Claim 67, wherein the further purge pulse comprises flowing purge gas from the first purge channel to the first apertures and to the reactant channel of the first injector.